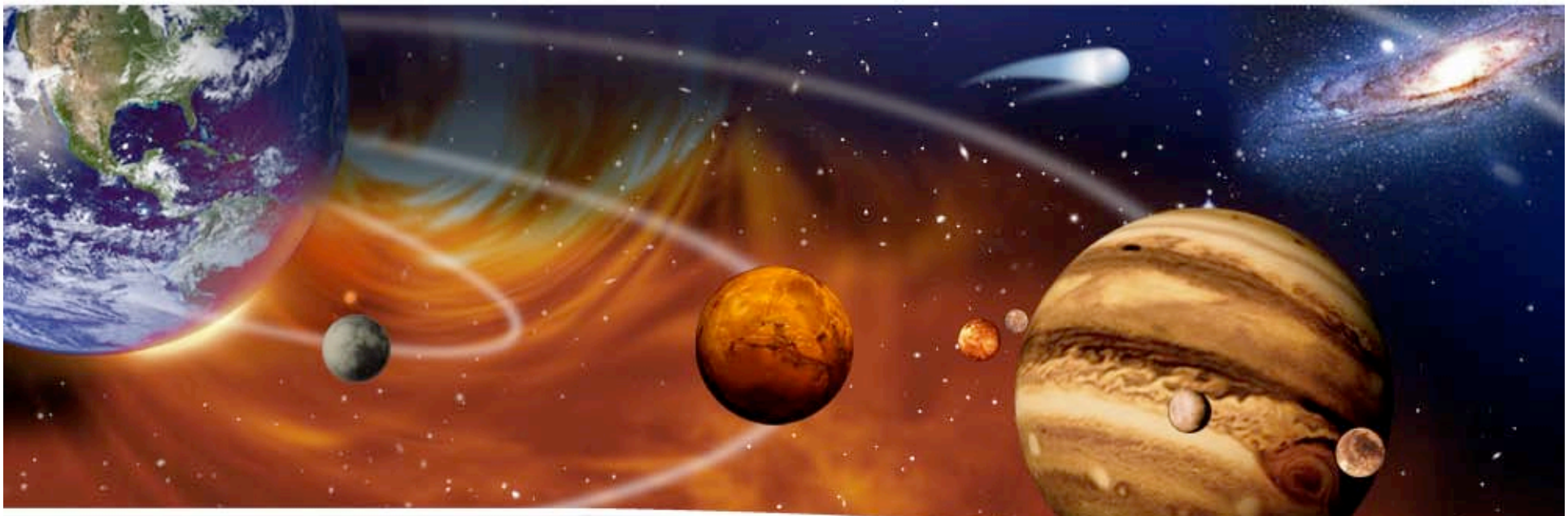


Earth Science Strategic Planning
&
The Vision for Space Exploration

Presentation to Roadmap #9 Team
Greg Williams

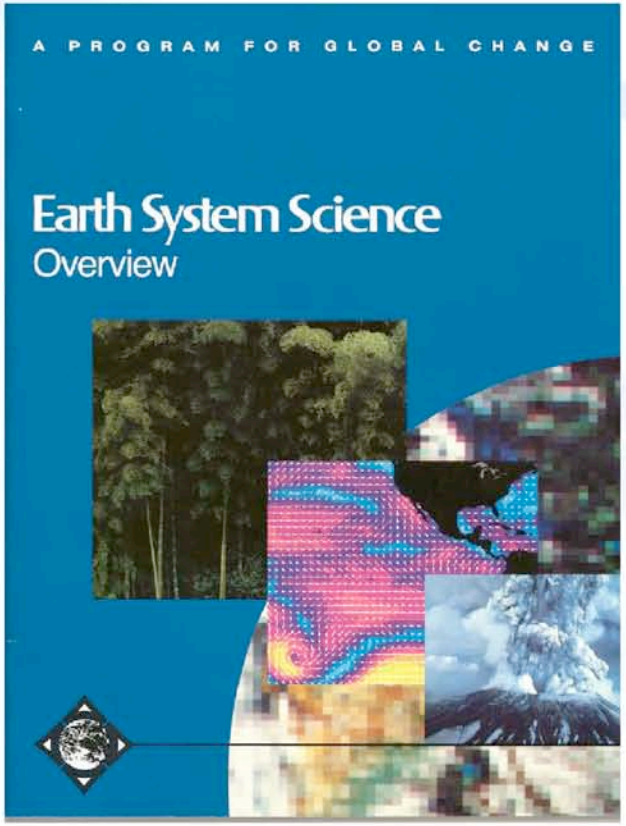
January 26, 2005

Contents

The Rise of Earth System Science

"**The Goal of Earth System Science** -- To obtain a scientific understanding of the entire Earth system on a global scale by describing how its component parts and their interactions evolved, how they function, and how they may be expected to evolve on all time scales"

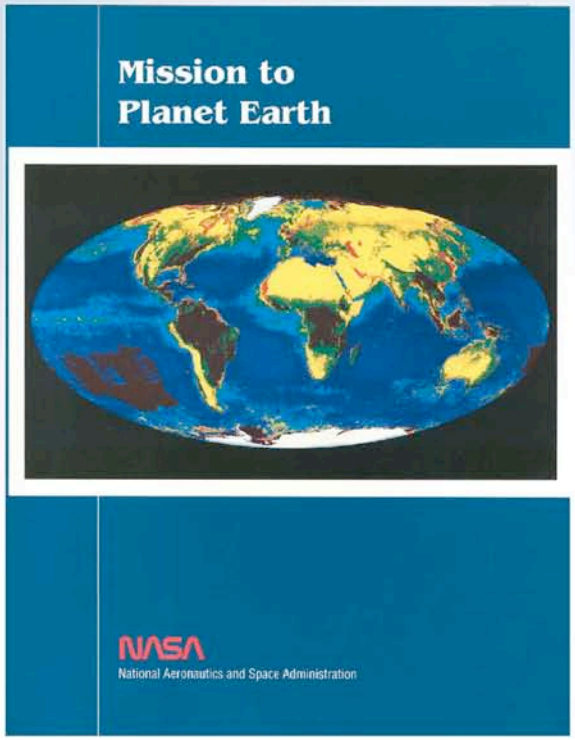
"**The Challenge of Earth System Science** -- To develop the capability to predict those changes that will occur in the next decade to century, both naturally and in response to human activities"

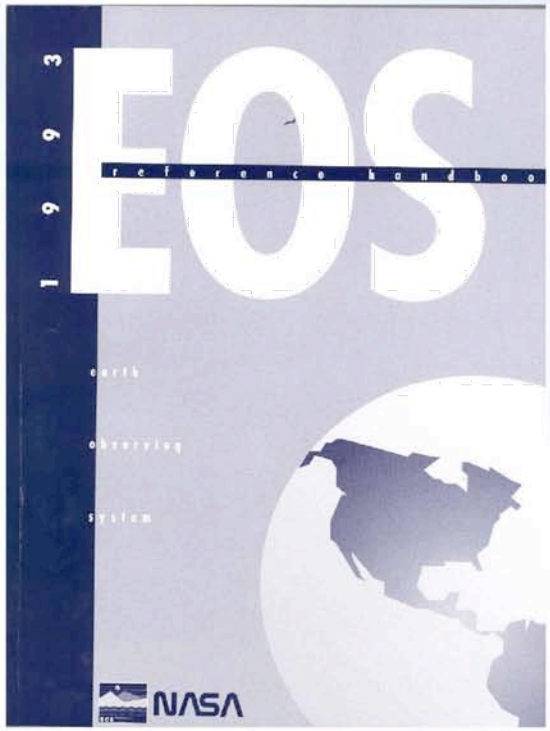


NASA Advisory Council
1986--88

From ESS to EOS

The Earth System Science concept resulted in the formulation of the Earth Observing System



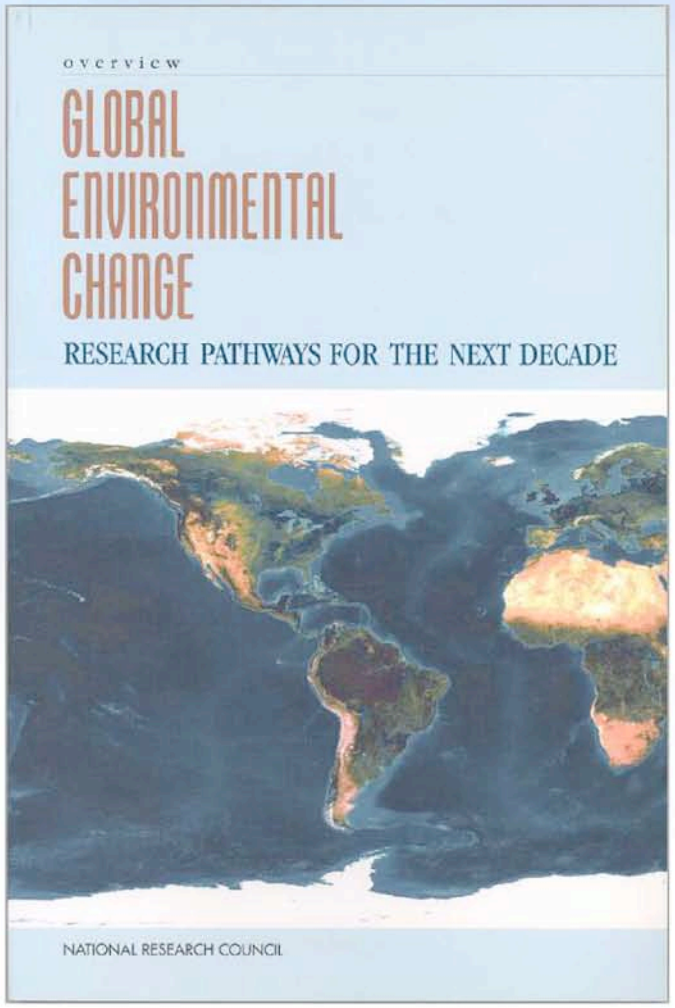


The Earth Observing System was inaugurated as a Presidential Initiative in 1991

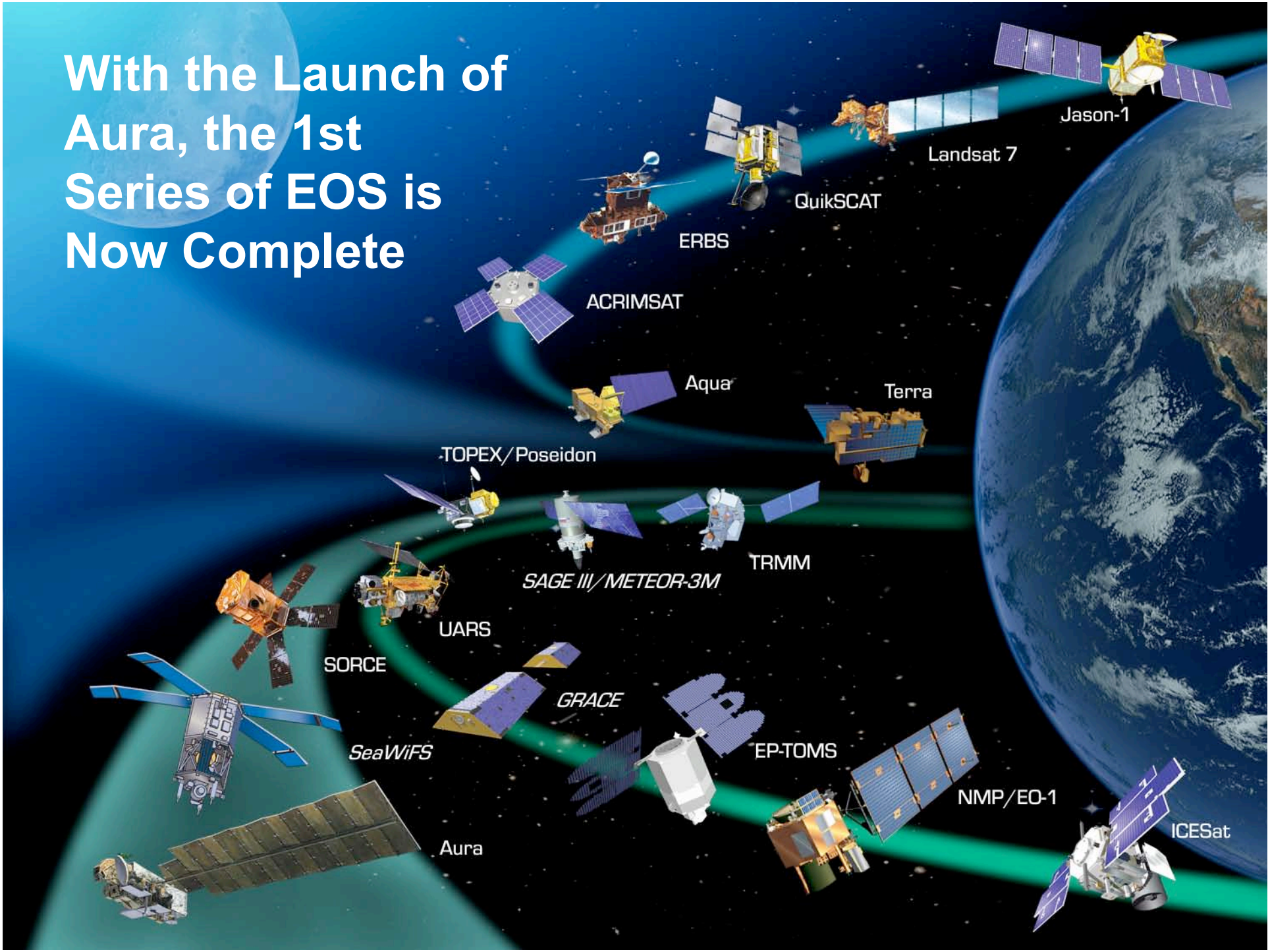
In the early/mid 90s, a series of design reviews led to the current multi-satellite configuration

"Pathways" Recommendations to USGCRP

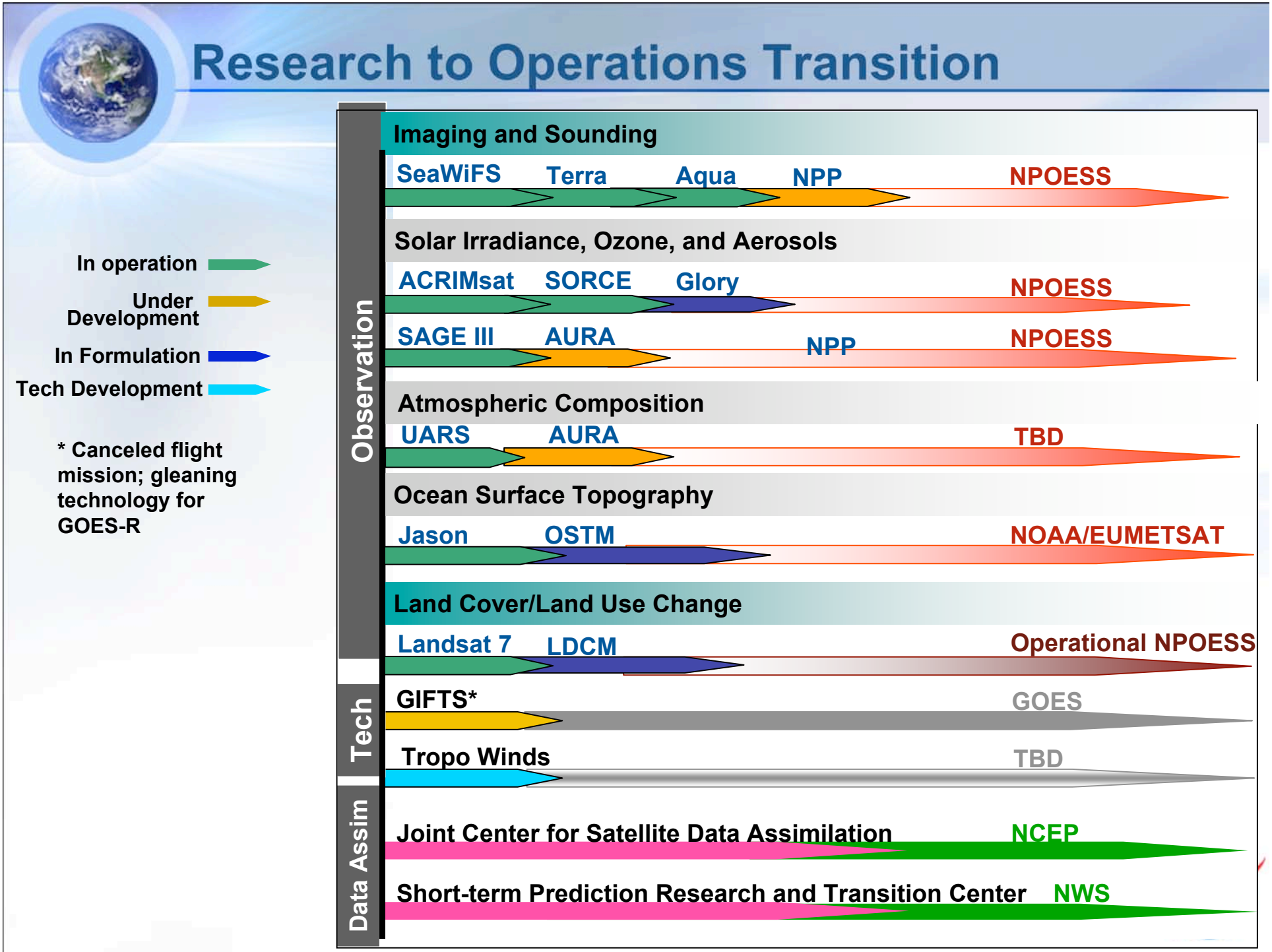
1998-99



- Tie resource allocations to unanswered science questions
- Restructured observing strategy must be driven by unanswered science questions
- Strategy for long-term observations must be reassessed to give priority to key variables
- Observing strategy should aggressively employ technology innovation
- Data system strategy should emphasize flexible, innovative systems, open access, and rapid evolution
- Foster development of models at time and space scales needed for process understanding, prediction, and informing policy processes


With the Launch of Aura, the 1st Series of EOS is Now Complete
Jason-1
Landsat 7
QuikSCAT
ERBS
ACRIMSAT
Aqua
Terra
TOPEX/Poseidon
TRMM
SAGE III/METEOR-3M
UARS
SORCE
GRACE
SeaWiFS
EP-TOMS
NMP/EO-1
ICESat
Aura

Research to Operations Transition

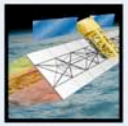


Future Missions

Next Generation Missions

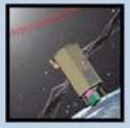
NPOESS Preparatory Project

Ocean Vector Winds Mission



Synthetic Aperture Radar

Calipso

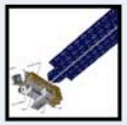


Orbiting Carbon Observatory

Blue Horizons

Landsat Data Continuity Mission Instruments

Global Precipitation Measurement



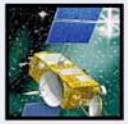
Chemistry/Climate Mission

Cloudsat

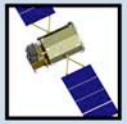
Aquarius

Restless Planet

Aiolos



Ocean Surface Topography Mission



Aerosol Polarimeter Sensor Instruments

Cryosphere Monitoring Mission

Hydros

Candidate Future Missions
In Formulation/Preformulation or in Development

Next generation systematic measurement missions to extend/enhance the record of science-quality global change data

Research missions to probe key Earth system processes globally for the first time

Future research Measurements

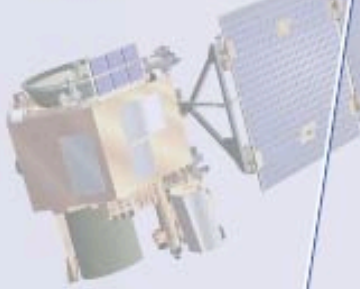
Earth Science Enterprise Strategy: Summary

- In dialog with the science community, choose scientific questions for which NASA technology and remote sensing can make a defining contribution
- Pursue answers to those questions via an end-to-end research program integrating technology development, Earth observation, data analysis, and data assimilation & modeling
- Transition mature observation capabilities / responsibilities to operational agencies
- Assist agency partners in demonstrating the utility of NASA observations and research results in those agencies' decision support systems
- Envision and create the next generation of research and technology

ESE Research is Part of an End-to-End Program of Science for Society

Earth Science for Society Framework

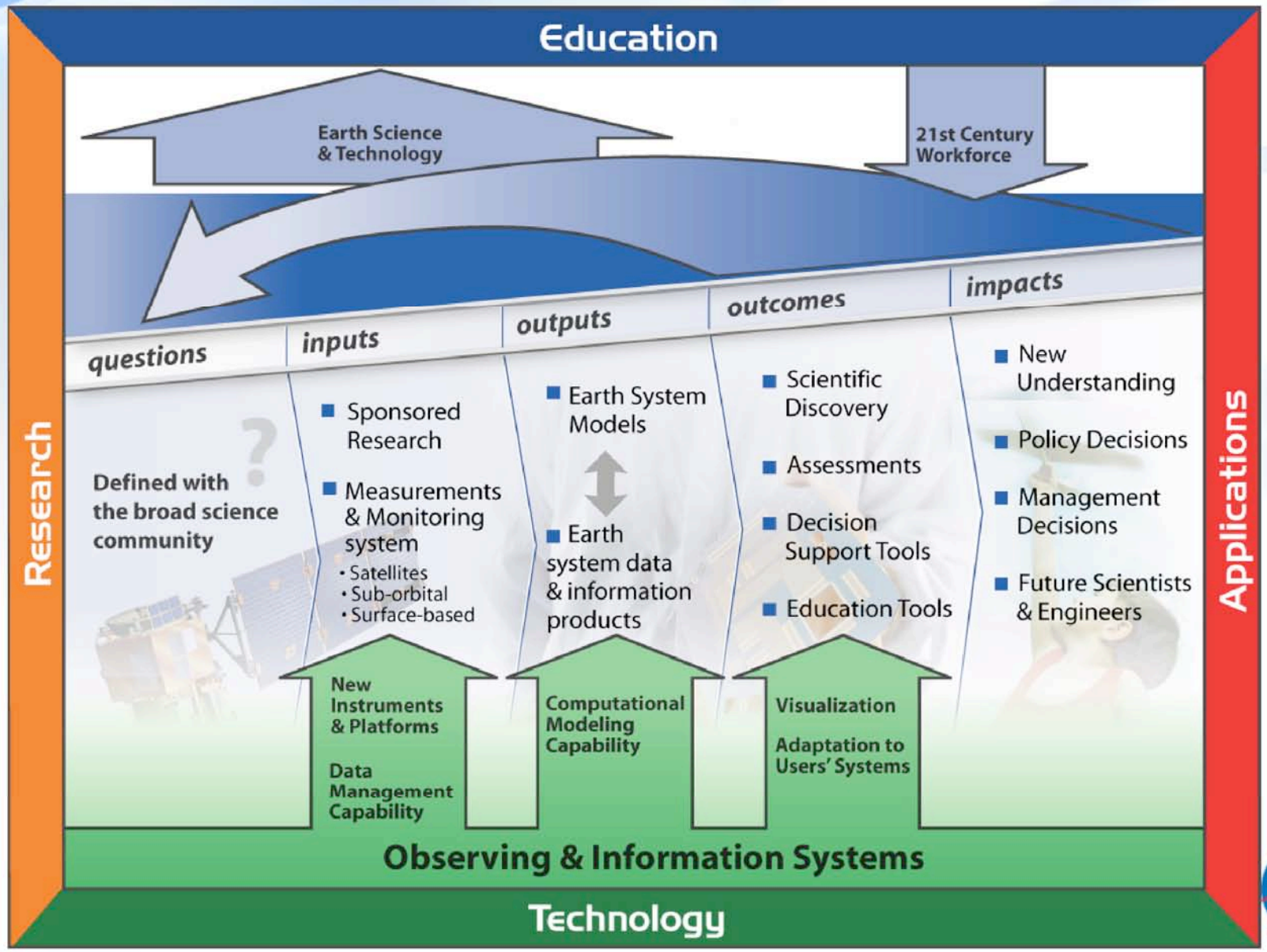
questions	inputs	outputs	outcomes	impacts
Defined with the broad science community	■ Sponsored Research ■ Measurements & Monitoring Systems • Satellites • Sub-orbital • Surface-based	■ Earth System Models ■ Earth System Data and Information Products	■ Scientific Discovery ■ Assessments ■ Decision Support Tools ■ Education Tools	■ New Understanding ■ Policy Decisions ■ Management Decisions ■ Future Scientists & Engineers



NASA & partner producers of Earth science information

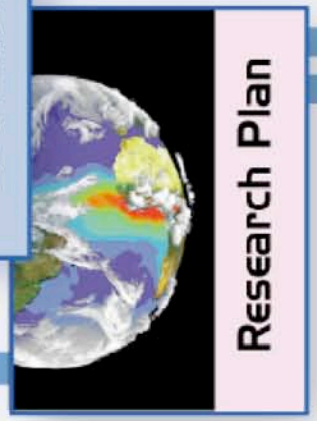
Users of Earth science information

ESE Research is Part of an End-to-End Program of Science for Society

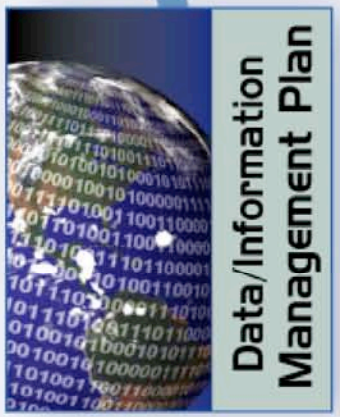


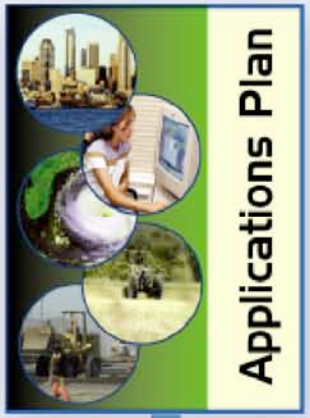
ESE Strategy Documents

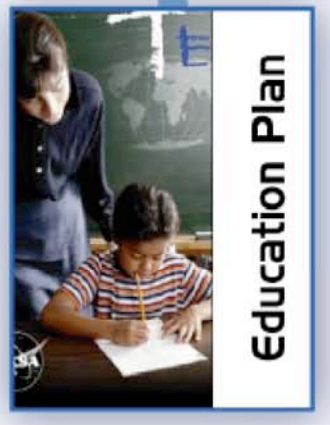
ESE Strategy Documents

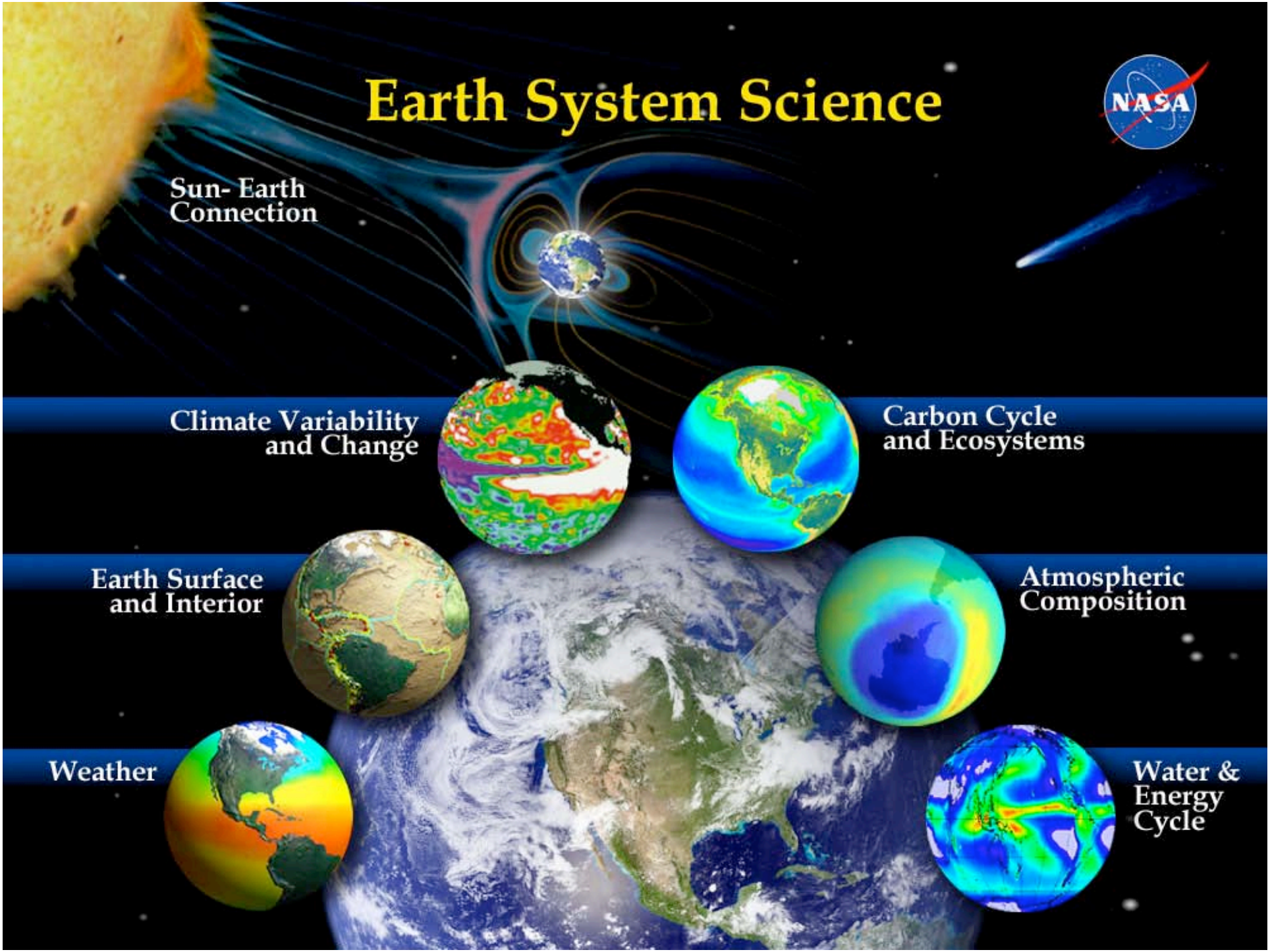


- Observing approach
- Computational modeling approach







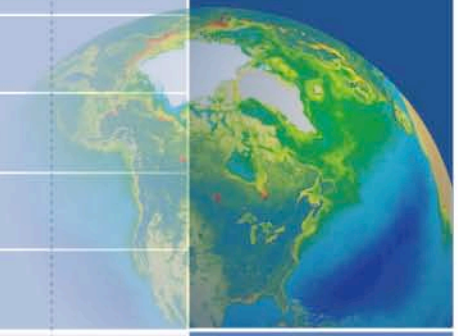

Earth System Science
NASA
Sun- Earth Connection
Climate Variability and Change
Carbon Cycle and Ecosystems
Earth Surface and Interior
Atmospheric Composition
Weather
Water & Energy Cycle

RoadMap
Carbon Cycle & Ecosystems

Field Campaign
Technology
Partnership
Unfunded
Funded

ACTIVITIES	OUTPUTS	GOALS
Human Ecosystems-Climate Interactions (Coupling Model-Data Fusion, Assimilation)	Integrated Global Analysis	Global productivity & land cover change at fine resolution; biomass & carbon fluxes quantified; useful ecological forecasts & improved climate change projections
T High-Resolution Atmospheric CO_2	Sub-regional sources/sinks	
T Profiles of Ocean Particles	Carbon export to deep ocean	
T Physiology & Functional Groups	Models w/improved ecosystem functions	
Southern Ocean Carbon Program	Process controls identified; errors in sink reduced	
T New Ocean Carbon/Coastal Event Observations	Reduced uncertainties in fluxes and coastal C dynamics	
T Vegetation 3-D Structure, Biomass & Disturbance	Terrestrial carbon stocks & species habitat characterized	
Global CH_4: Wetlands, Flooding & Permafrost	CH_4 sources characterized and quantified	
Global Atmospheric CO_2(OCO)	Regional carbon sources/sinks quantified for planet	
North American Carbon Program	North America's carbon budget quantified	
Land Use Change in Amazonia	Effects of tropical deforestation quantified; uncertainties in tropical carbon source reduced	
Landsat	LDCM	LDCM II
Ocean Color (SeaWiFS, MODIS) Vegetation (AVHRR, MODIS)	Ocean Color/Vegetation (VIIRS/NPP)	Ocean/Land (VIRS/NPOESS)
Case Studies	Process Understanding	Models & Computing Capacity
IPCC NA Carbon	NA Carbon	IPCC Global C Cycle Global C Cycle

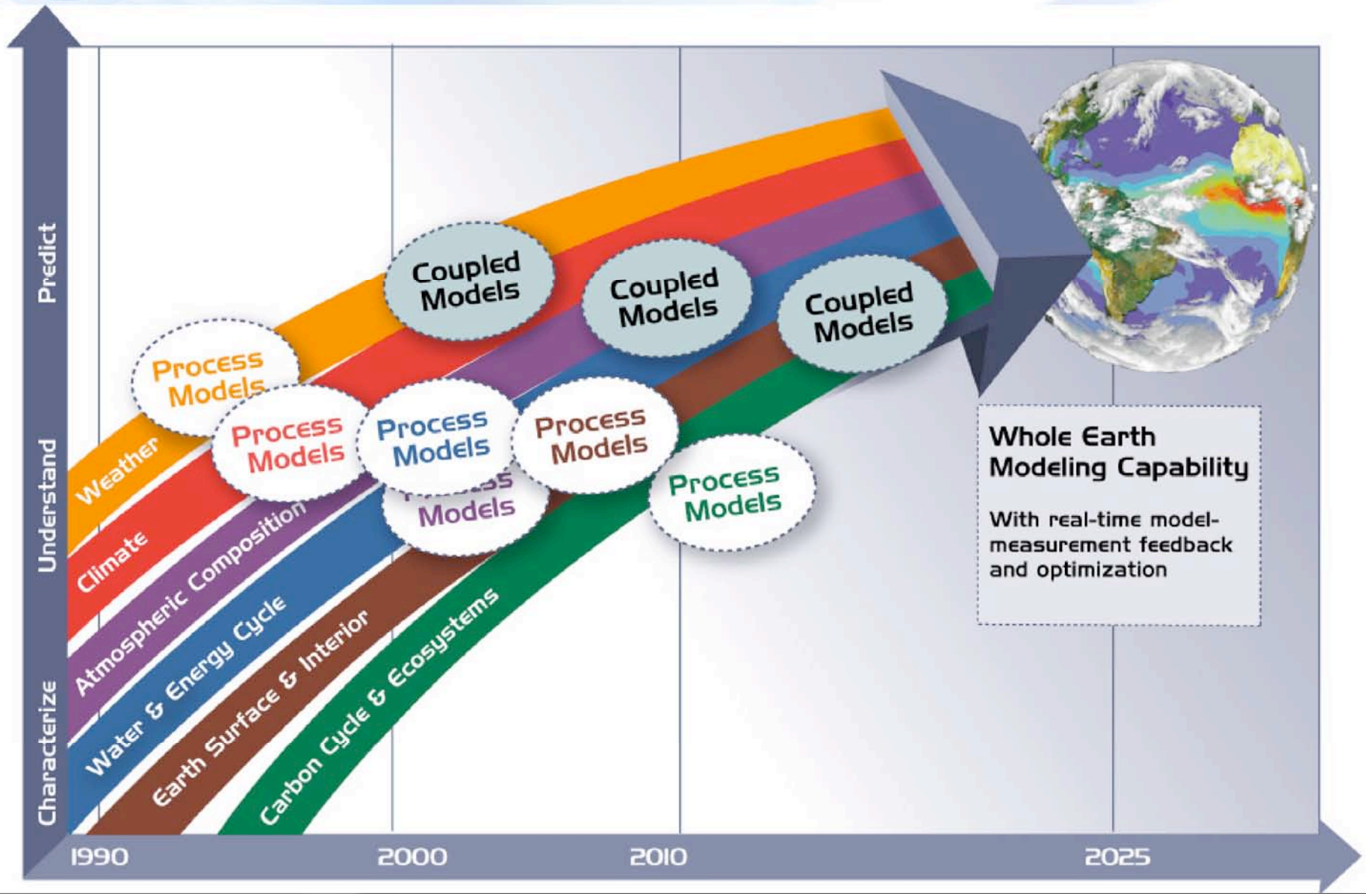
SYSTEMATIC OBSERVATIONS
IMPROVEMENTS
REPORTS

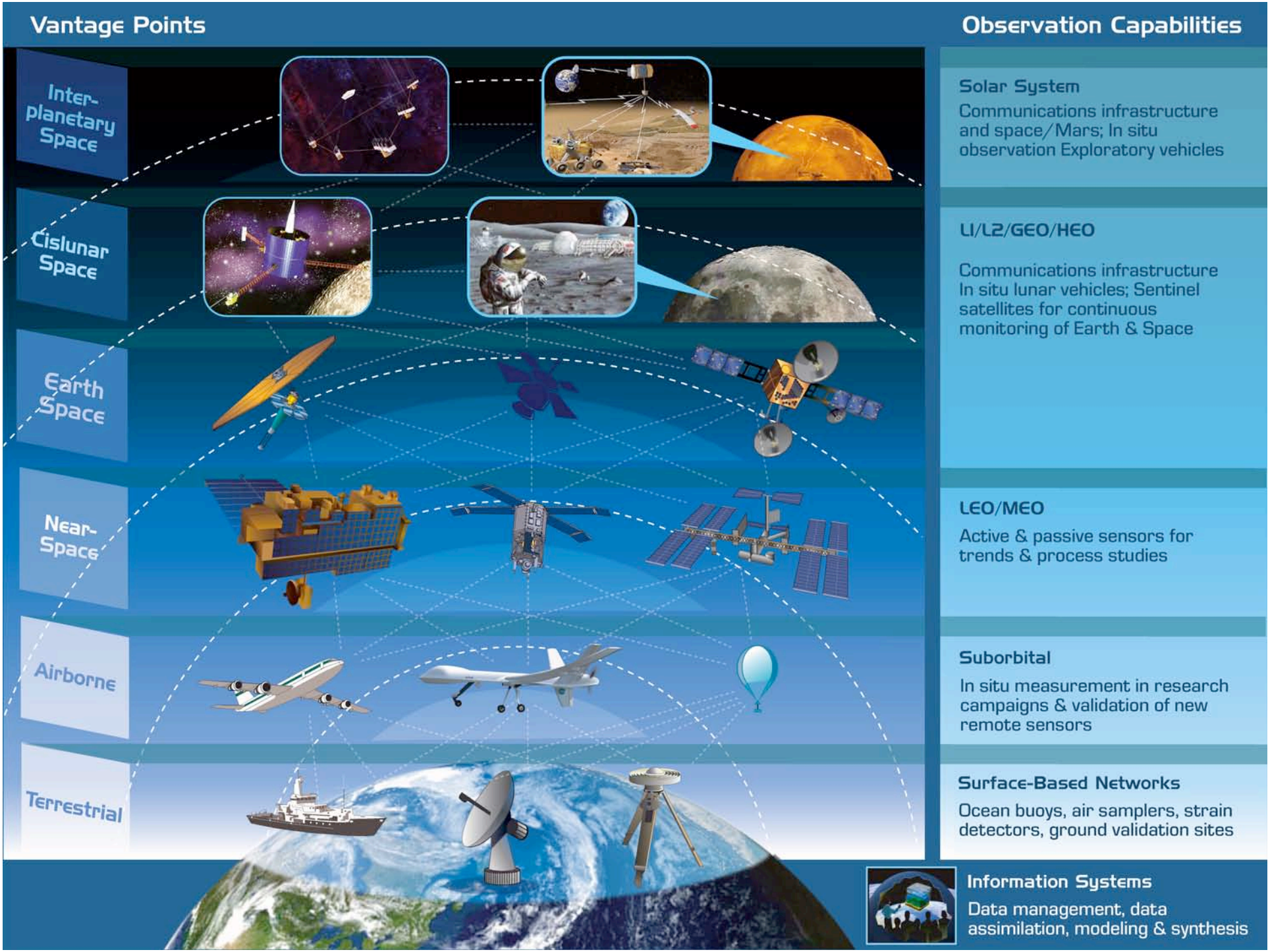


Knowledge Base Development

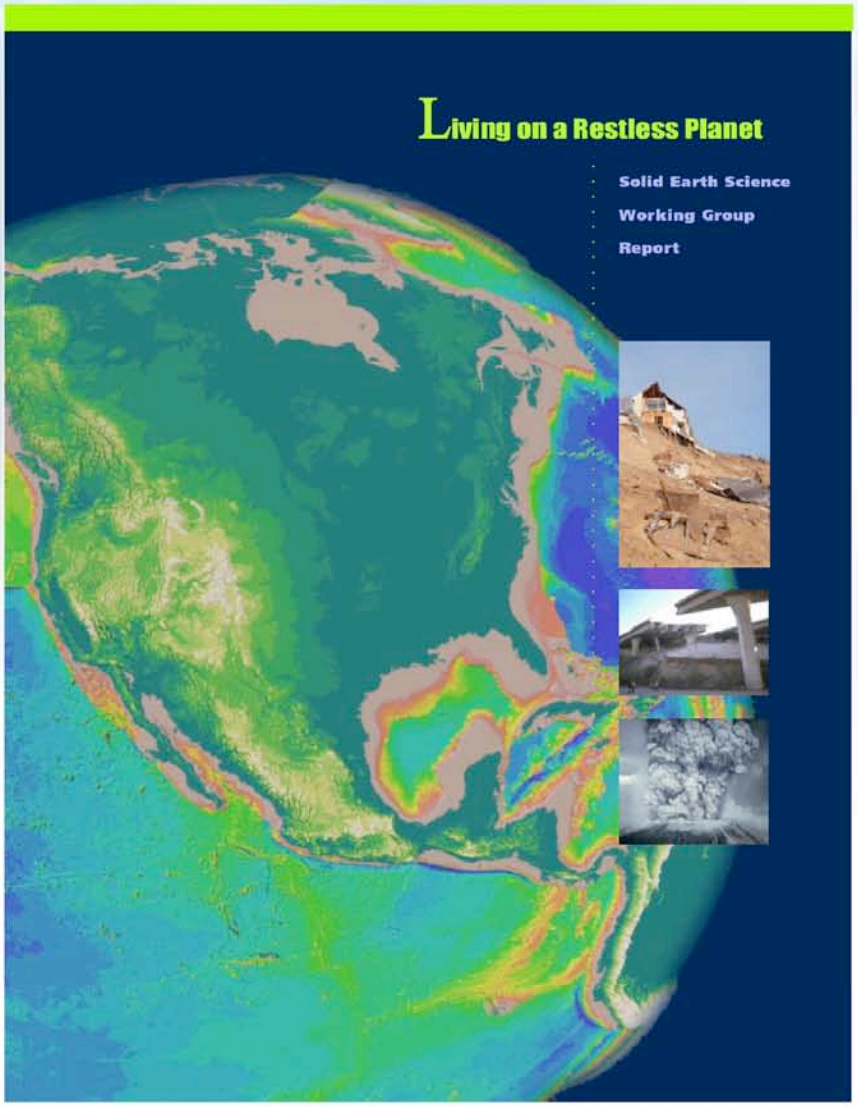
2002 2004 2006 2008 2010 2012 2014 2015

Focus Area Integration via Earth System Modeling




Vantage Points
Observation Capabilities
Inter-planetary Space
Cislunar Space
Earth Space
Near-Space
Airborne
Terrestrial
Solar System
Communications infrastructure and space/Mars; In situ observation Exploratory vehicles
L1/L2/GEO/HEO
Communications infrastructure In situ lunar vehicles; Sentinel satellites for continuous monitoring of Earth & Space
LEO/MEO
Active & passive sensors for trends & process studies
Suborbital
In situ measurement in research campaigns & validation of new remote sensors
Surface-Based Networks
Ocean buoys, air samplers, strain detectors, ground validation sites
Information Systems
Data management, data assimilation, modeling & synthesis

Solid Earth Science Working Group



Earth Surface & Interior was the first of the Science Focus Areas to be the subject of an externally-led study to set priorities for the future.

The SESWG report has been reviewed, and its priorities for NASA endorsed, by the NRC.

Analogous groups for other focus areas are being established, beginning with Atmospheric Composition.

Today's National Context

NASA's Earth Science program has "a critical role in implementing *three* major Presidential directives"*:

Global Change Research

The Climate Change Research Initiative and US Global Change Research Program have been integrated in the US Climate Change Science Program

Global Earth Observation

Building on the international Earth Observation Summit (July 31, 2003), participating nations are forging a 10 year plan

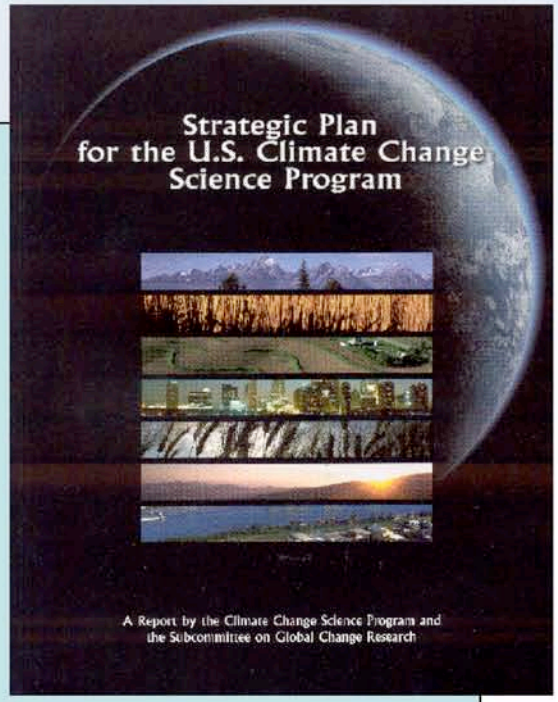
Vision for Space Exploration

Earth science has important contributions to make in research, observing technologies, and information systems

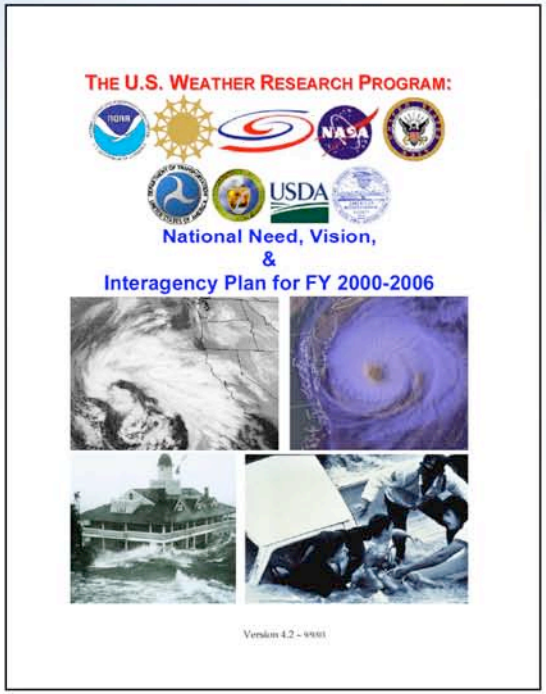
"…NASA's Earth science programs are *essential* to the success of the first two, and will surely prove to be so to the third."*

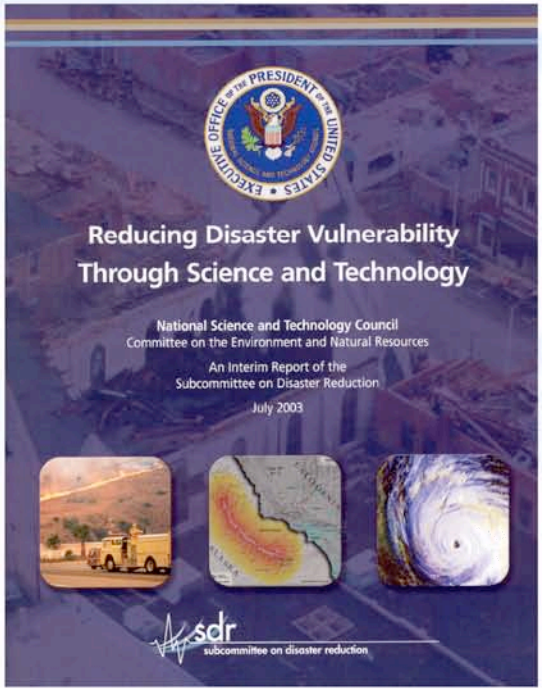
* Observation by ESSAAC in deliberations on the future of Earth science at NASA

Interagency Plans Now Exist, and Will Evolve, for Climate, Weather & Natural Hazards



CCTP Plan





What should *NASA* do??

GEOSS:
Global Earth Observation System of Systems

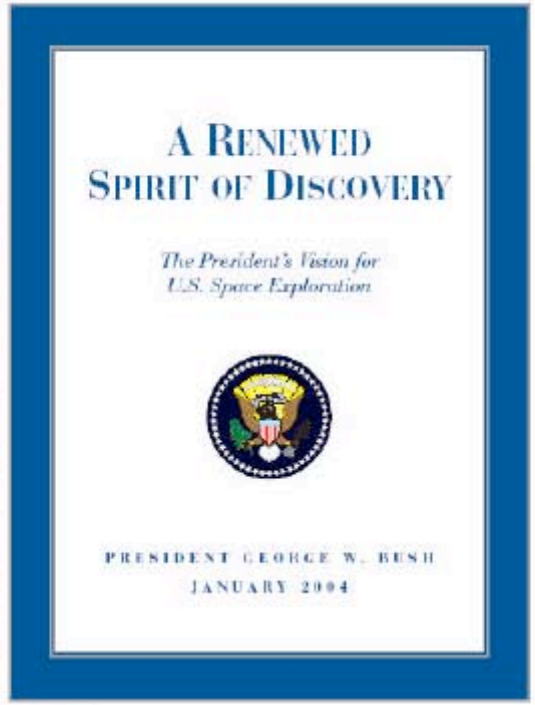
Earth Observations Summit

Observations to Users to Benefits

And the U.S. Interagency Working Group on Global Earth Observation

The Vision for Space Exploration

Presidential Direction to NASA, January 2004



- Implement a sustained and affordable human and robotic program to explore the solar system and beyond

- Extend human presence across the solar system, starting with a human return to the Moon by the year 2020, in preparation for human exploration of Mars and other destinations;

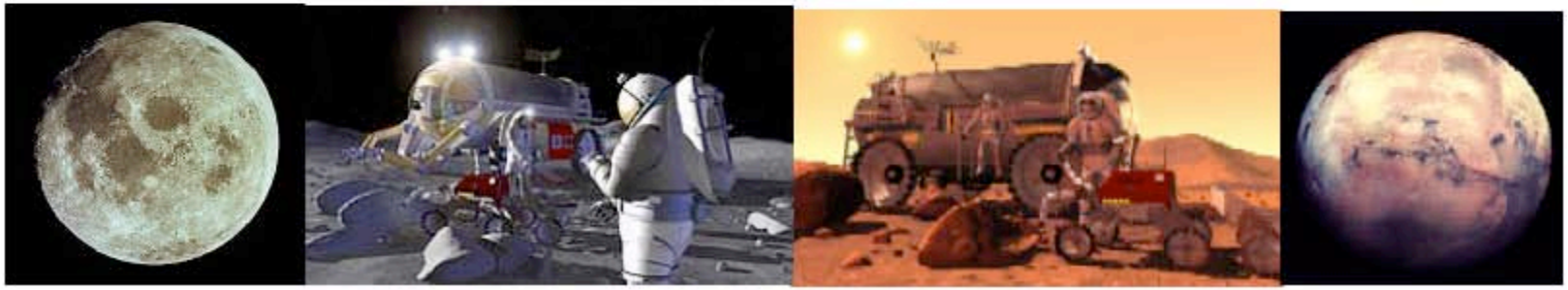
- Develop the innovative technologies, knowledge, and infrastructures both to explore and to support decisions about the destinations for human exploration; and

- Promote international and commercial participation in exploration to further U.S. scientific, security, and economic interests.

The Vision's Evolutionary Strategy

Demonstrate Capability, Extend Exploration

- **Technology advancement** reduces mission costs and supports expanded human exploration
- **Systems testing** and technology test beds to develop reliability in harsh environments
- **Expand mission and science surface operations** experience and techniques
- **Human and machine collaboration:** Machines serve as an extension of human explorers, together achieving more than either can do alone
- **Breaking the bonds of dependence on Earth**: (e.g./Life Science/Closed loop life support tests)
- **Power generation and propulsion** development and testing
- **Common investments** in hardware systems for Moon, Mars and other space objectives



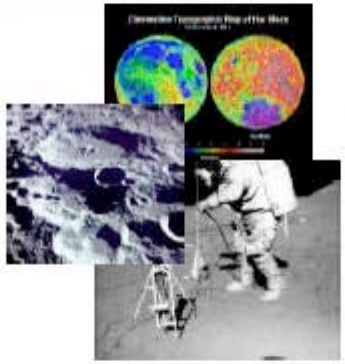
The Vision's Science

All Destinations Play a Role

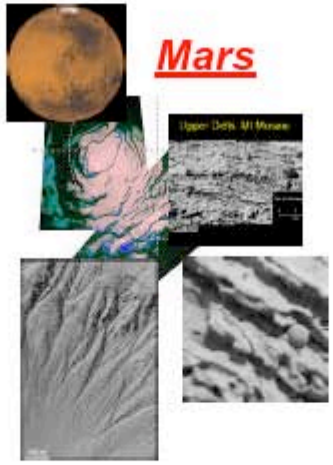
Search for Life as a Focus

- What do our studies of planetary systems and biogeochemistry tell us about the past and present habitability of planets?
- What signatures would suggest evidence of organic activity or habitability in planetary systems?
- Have planets or moons in our Solar System supported life in the past or the present?
- How abundant are planets around other stars and do they show evidence of habitability or life?

Earth's Moon

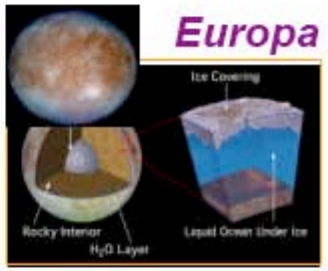


Mars



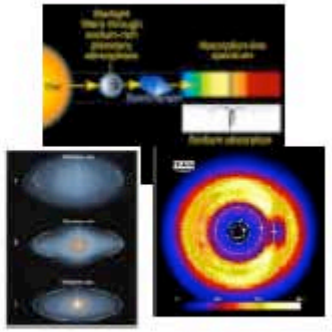
Outer Planets

Europa

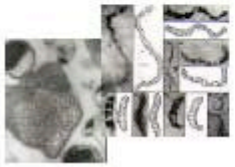


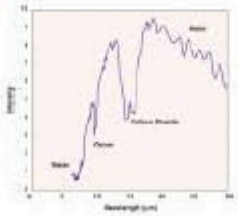
Titan

Extra-Solar Planets

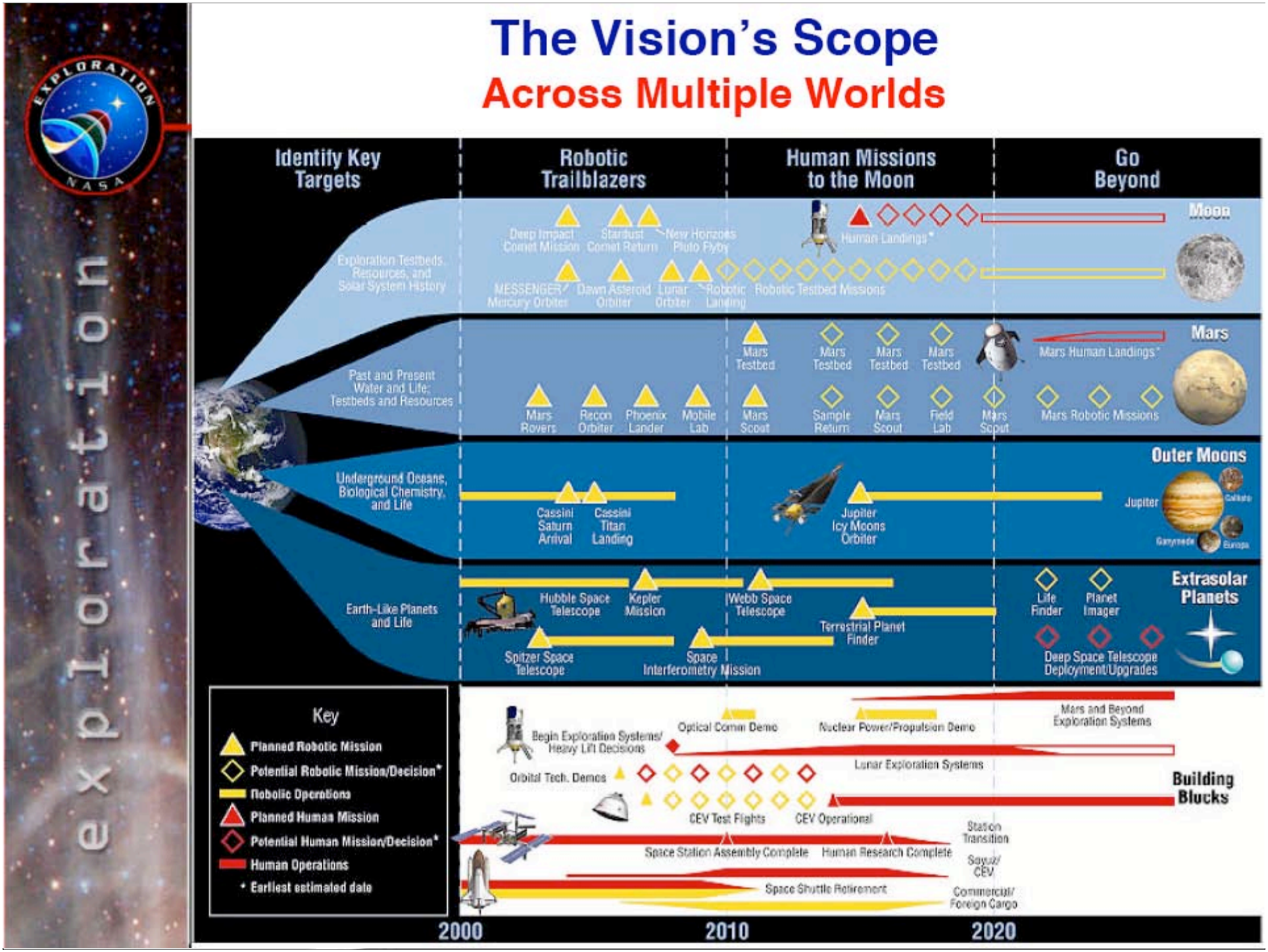


Astrobiology





The Vision's Scope
Across Multiple Worlds



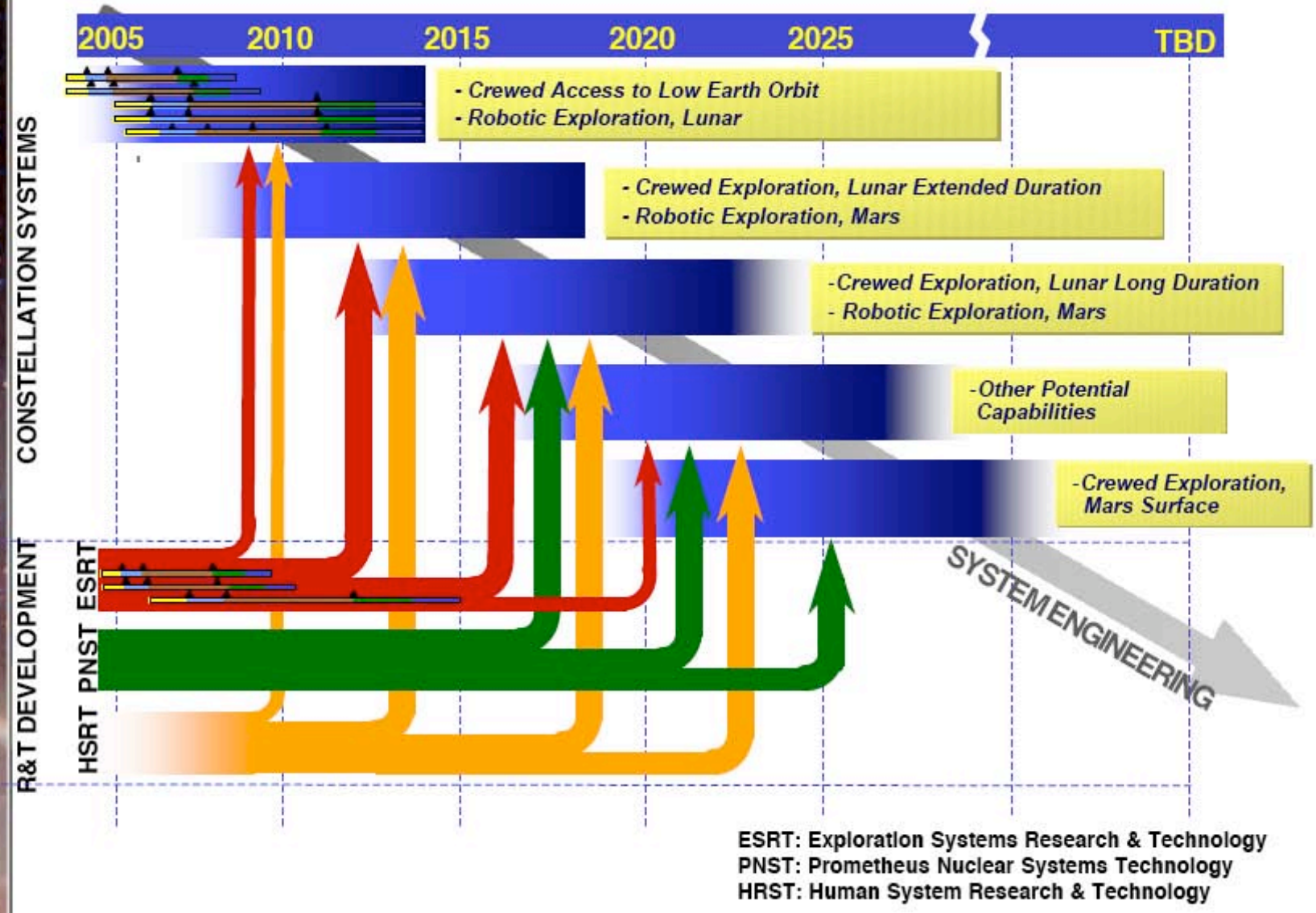
Exploration Milestones

Incremental milestones demonstrate success:

- ***2008: Initial flight test of CEV***
- ***2008: Launch first lunar robotic orbiter***
- ***2009-2010: Robotic mission to lunar surface***
- ***2011 First Uncrewed CEV flight***
- ***2014: First crewed CEV flight***
- ***2012-2015: Prometheus-1 Nuclear Demonstration***
- ***2015-2020: First human mission to the moon***

Spiral Development Acquisition Strategy

Permits Optimal System-of-Systems Development



ESRT: Exploration Systems Research & Technology
PNST: Prometheus Nuclear Systems Technology
HRST: Human System Research & Technology

Explore With Us!

www.nasa.gov

Returning to Earth for a Moment…

NRC Decadal Survey for Earth System Science

"…look afresh into the future and help NASA chart its course ahead."

What are the significant advances in Earth system science over the past decade?

What are the principal science questions that remain to be answered?

What measurements are most critical to answering those questions?

What types of next generation observing capabilities and orbital vantage points will best enable progress?

Oct. 29, 2003 Letter of request

What opportunities are afforded by the Exploration Vision and NASA Transformation?

July 7, 2004 letter

Presented by Rick Anthes at AMS…

Organization of Study

- Executive Committee (~ 18 members)
- Seven Thematic Panels
  1. Earth Science Applications and Societal Needs
  2. Land-use Change, Ecosystem Dynamics and Biodiversity
  3. Weather (incl. space weather and chemical weather)
  4. Climate Variability and Change
  5. Water Resources and the Global Hydrologic Cycle
  6. Human Health and Security
  7. Solid-Earth Hazards, Resources and Dynamics

Decadal Survey Panels	**Atmosphere**	**Hydrosphere and Cryosphere**	**Oceans**	**Land (land cover, ecosystems, humans)**	**Solid Earth**	**Earth's Space Environment and Sun-Earth Connection**
1. Earth Science Applications and Societal Objectives	x	x	x	x	x	x
2. Land –use Change, Ecosystem Dynamics and Biodiversity	x	x	x	x		
3. Weather (incl. Chemical and Space Weather	x	x	x	x		x
4. Climate Variability and Change	x	x	x	x		x
5. Water Resources and the Global Hydrologic Cycle	x	x	x	x	x	
6. Human Health and Security	x	x	x	x		
7. Solid-Earth Hazards,Resources and Dynamics		x	x	x	x	x

CHARGE TO COMMITTEE

- **Recommend a prioritized list of flight missions and supporting activities** within NASA and NOAA to support national needs for research and monitoring of the dynamic Earth system during the decade 2005-2015.

- **Identify important directions that should influence planning for the decade beyond 2015.** For example, the committee will consider what ground-based and in-situ capabilities are anticipated over the next 10-20 years and how future space-based observing systems might leverage these capabilities.

Activities So Far

- **August 23-26-Woods Hole Workshop**
- **Appointed Executive Committee and most of seven Panels**
- **November 8-9-First meeting of Executive Committee in Washington**
- **December 14-Town meeting at AGU**
- **January 5-6-Second meeting of Ex Com in Irvine**
- **January 10-Town meeting at AMS**

Study Products

- First report February/March 2005
  - Asked for by House Science Committee Staffers at 8-9 Nov meeting of Ex Committee
  - Short, unambiguous, and very specific about new missions for NASA and NOAA
  - We agreed to produce such a report and assigned writing assignments to Committee members
  - What should be started immediately
- Second and Final report (4/06)
  - Address rest of charge
  - Longer term

First Report

- About 10 pages long-letter report
- Follow guiding principles and criteria for prioritization
- Propose a few key, or benchmark observations
- Give NASA and NOAA specific, unambiguous guidance
- Give Congress ammunition to save Earth Sciences in NASA!
- Support the GEOSS
- Test ability of Ex Com to produce a prioritized list of missions
- Get NASA and NOAA started on a few high-priority missions
- Get funding lines in place for new missions
- Take some high-priority missions “off the table,” making room for new missions in Phase II recommendations.

Next Steps

- Executive Committee (EC) writes Phase I report-final draft due March 1!
- Panels begin work on Phase II
- Solicit ideas and “proposals” from community
  - RFI out by 15 January
  - Response due March 15, 2005

Phase II

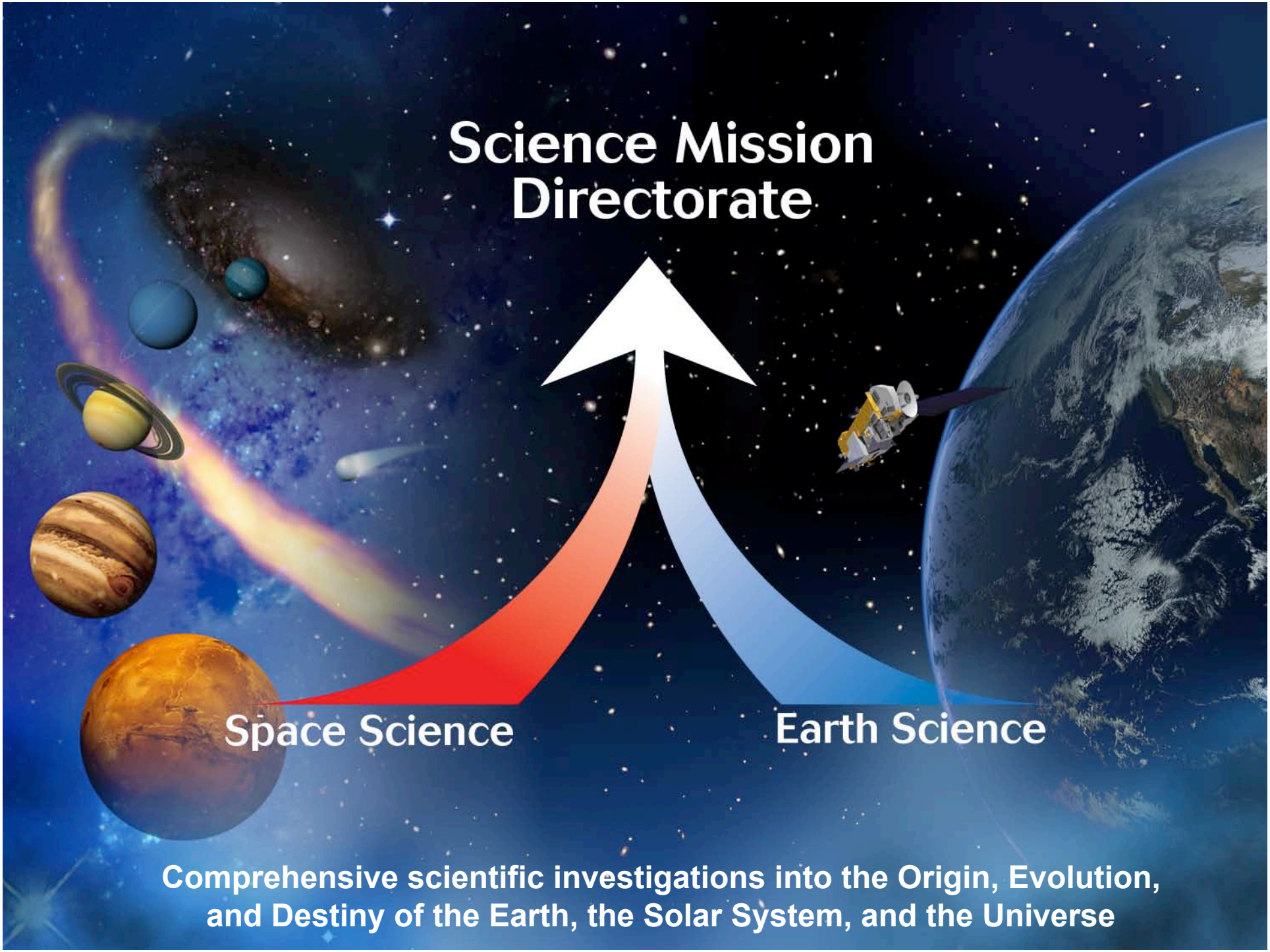
- First input from panels due June 1, 2005.
- EC and staff analyze and integrate panel input (June-July), prepare detailed outline of first draft
- EC and panels meet in August 2005 at Woods Hole
- First draft by Nov 2005
- Discuss first draft at AGU in Dec 05 and AMS in January 06

NRC Decadal Survey & NASA Roadmapping

The Decadal Survey planning committee was informed by Mr. Diaz in August that we will look to them to be the review committee for Strategic Roadmap #9; under discussion by the committee

The SSB Committee on Solar & Space Physics (CSSP) is a standing committee that has reviewed NASA roadmaps in this discipline in the past, and will likely be called upon to review Roadmap #10

SSB staff is considering options, e.g., an ad hoc committee comprising members of the Decadal Survey committee and the CCSP to review Roadmap #9


Science Mission Directorate
Space Science
Earth Science
Comprehensive scientific investigations into the Origin, Evolution, and Destiny of the Earth, the Solar System, and the Universe

Revised Objective

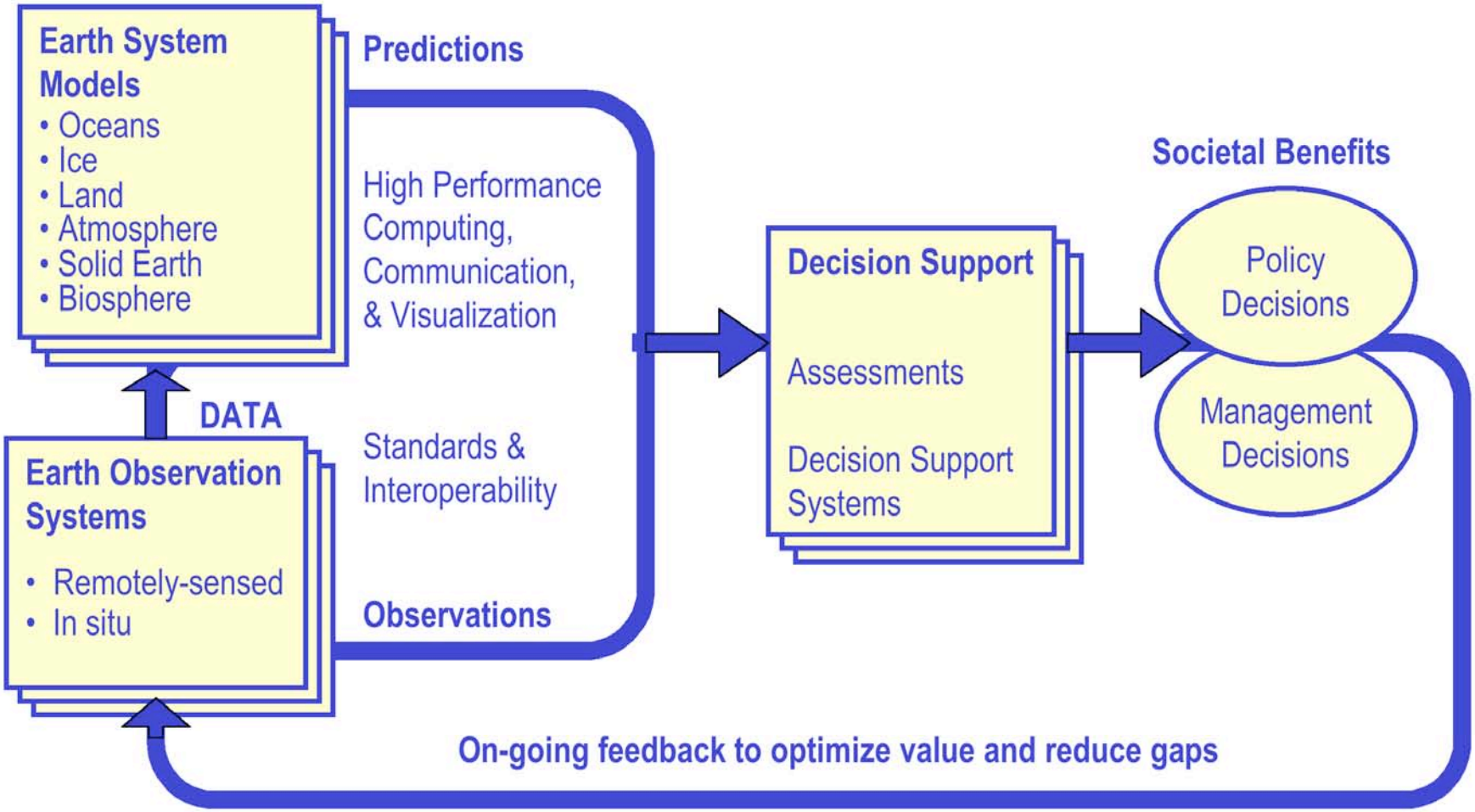
National Goal #5: Study the Earth system from space and develop new space-based and related capabilities for this purpose.

Strategic Objective #14: Advance scientific knowledge of the Earth system through space-based observation, assimilation of new observations, and development and deployment of enabling technologies, systems, and capabilities including those with the potential to improve future operational systems. (Roadmap #9)

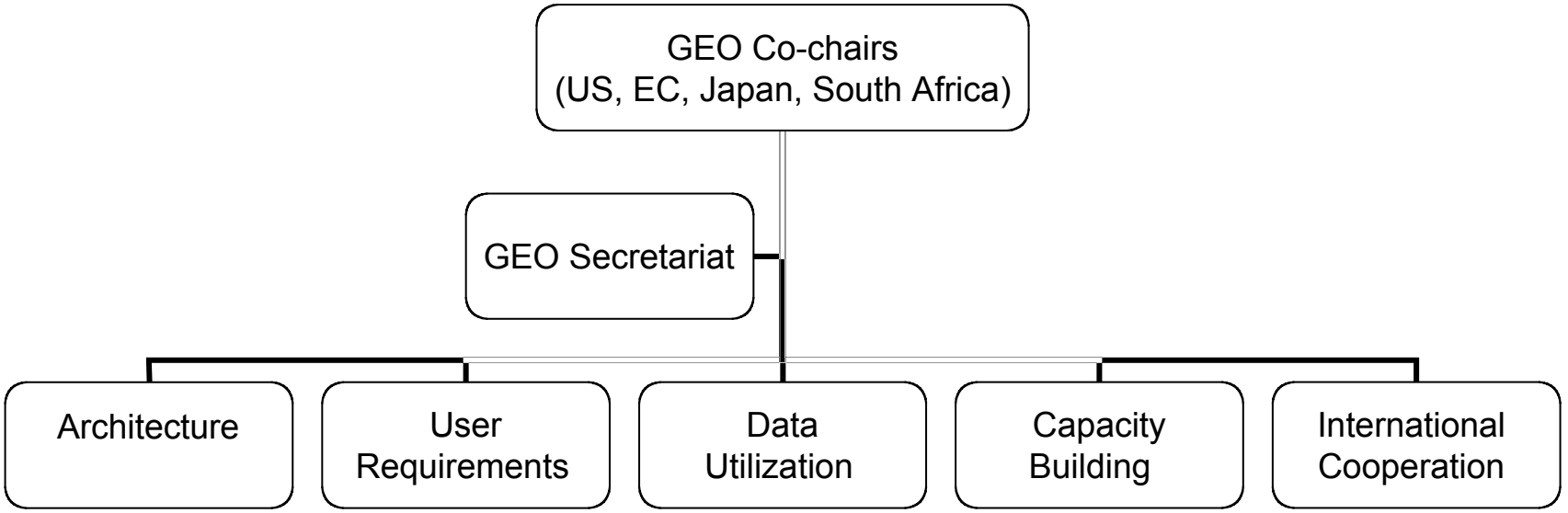
Back-up

Interagency Working Group on Earth Observations

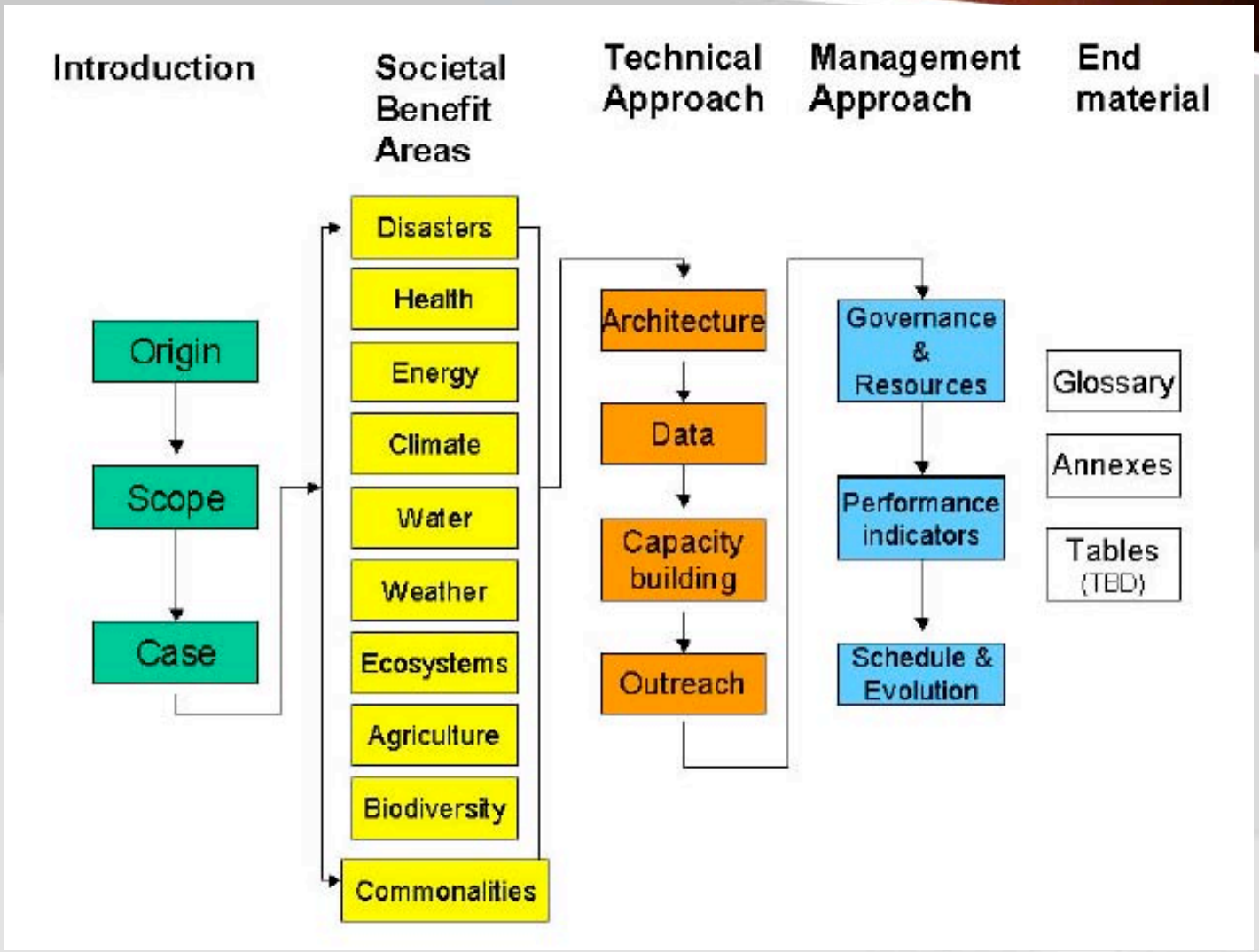
Architecture: Integrated Solutions



GEO (Group on Earth Observation)



Document Plan



GEO and GEOSS – NASA Participation

1. NASA is hosting the web sites for *ad hoc* Group on Earth Observations (earthobservations.org)
2. NASA provides an alternate to the *ad hoc* Group on Earth Observations Architecture Group (Ron Birk)
3. NASA provides a member of the GEO Secretariat (Peter Meister)
4. NASA is recognized for the 18 research satellites on orbit and 12 in development (http://www.esa.ssc.nasa.gov/m2m/)
5. NASA is recognized for the EOSDIS, DAACs, and REASoN projects that contribute to the U.S. capacity for data management of Earth observations
6. NASA is recognized for the geospatial interoperability and participation in the OpenGIS Consortium and the Federal Geographic Data Committee (FGDC)
7. NASA Applied Sciences Program applications are aligned with the GEO societal benefit areas (as conveyed in the web site at www.earth.nasa.gov/eseapps)
8. NASA is collaborating with IGARSS, IEEE, and an Industry Alliance on workshops and conferences focused on GEOSS

Global Earth Observation System of Systems (GEOSS)

Interagency Working Group on Earth Observations

IWGEO – NASA Participation

1. NASA is hosting the web site for IWGEO (iwgeo.ssc.nasa.gov)

2. NASA co-chairs the IWGEO (Dr. Ghassem Asrar) and co-leads the Planning and Integration Team of the IWGEO (Ron Birk).

3. NASA provides representatives to each of the IWGEO technical teams (Carroll, Turner, Maiden, Shepherd, Johnston) and societal benefit area writing teams.

4. NASA is recognized for the 18 research satellites on orbit and 12 in development (http://www.esa.ssc.nasa.gov/m2m/)

5. NASA is recognized for the EOSDIS, DAACs, and REASoN projects that contribute to the U.S. capacity for data management of Earth observations.

6. NASA is recognized for the geospatial interoperability and participation in the OpenGIS Consortium and the Federal Geographic Data Committee

7. NASA provides the editing and writing support for the IWGEO

8. NASA and IWGEO societal benefit areas and architecture are aligned (www.earth.nasa.gov/eseapps/drivers.html)

Senior Review for Earth Science Orbiting Missions

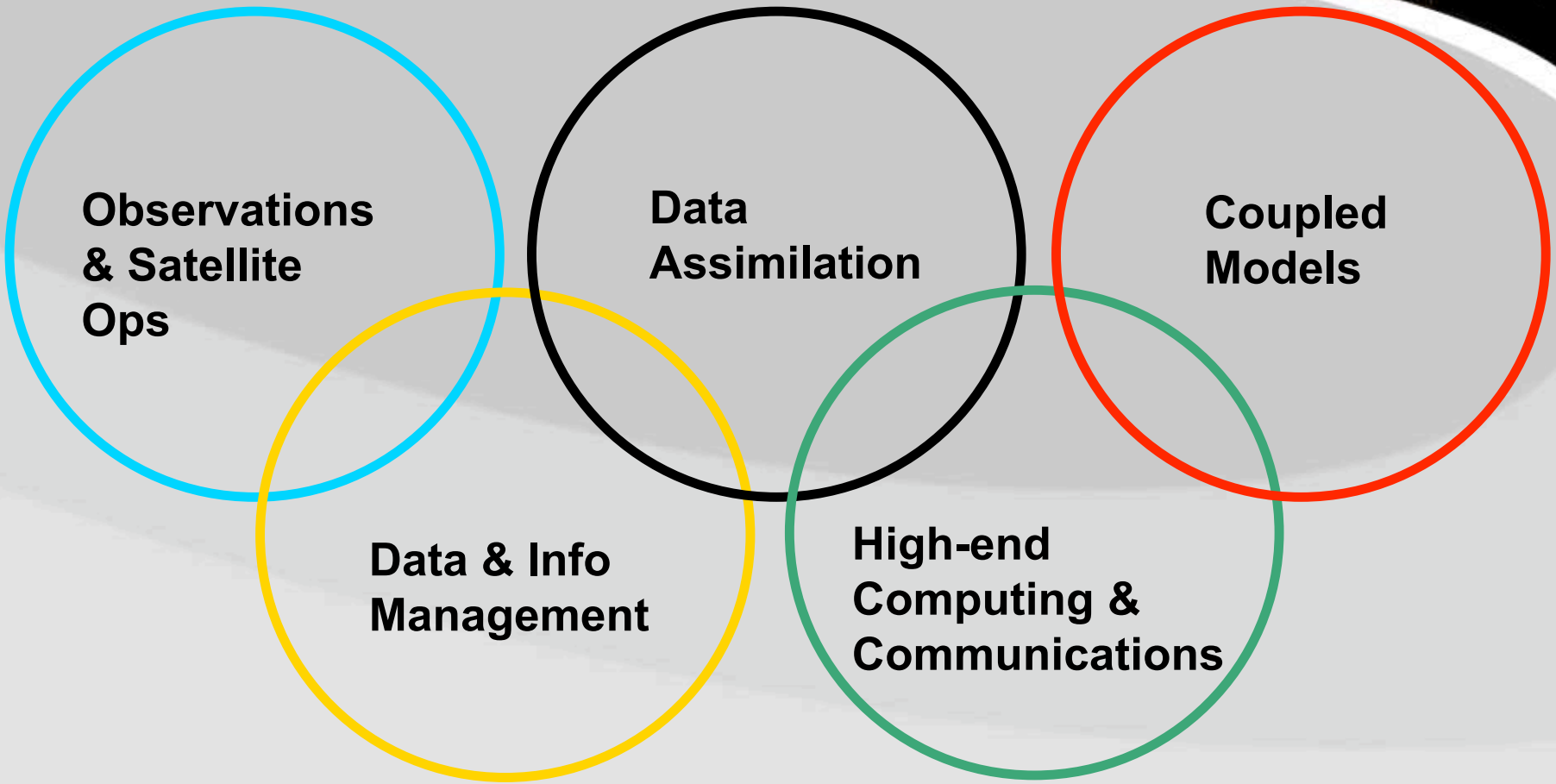
The Sun-Earth Systems division is organizing a Senior Review for our currently operating missions either in extended mission phase or about to enter the extended mission phase.

The Senior Review process will provide us with a set of recommendations regarding the relative science value of each the missions under consideration. The recommendations will consider the costs to NASA for conducting the science missions.

The panel will be composed of senior scientists from the Earth Science research community. This panel will review science proposals submitted by each of these missions: (tentative) ACRIM, ICESAT, JASON, QUIKSCAT, SAGE III, SORCE, TERRA, TOMS, TRMM, and UARS.

The review will be held on April 25-29 (tentative), 2005. The results and recommendations will permit us to make decisions concerning mission MO&DA budgets for FY-06-09.

We Need an End-to-End View of Science Information Management

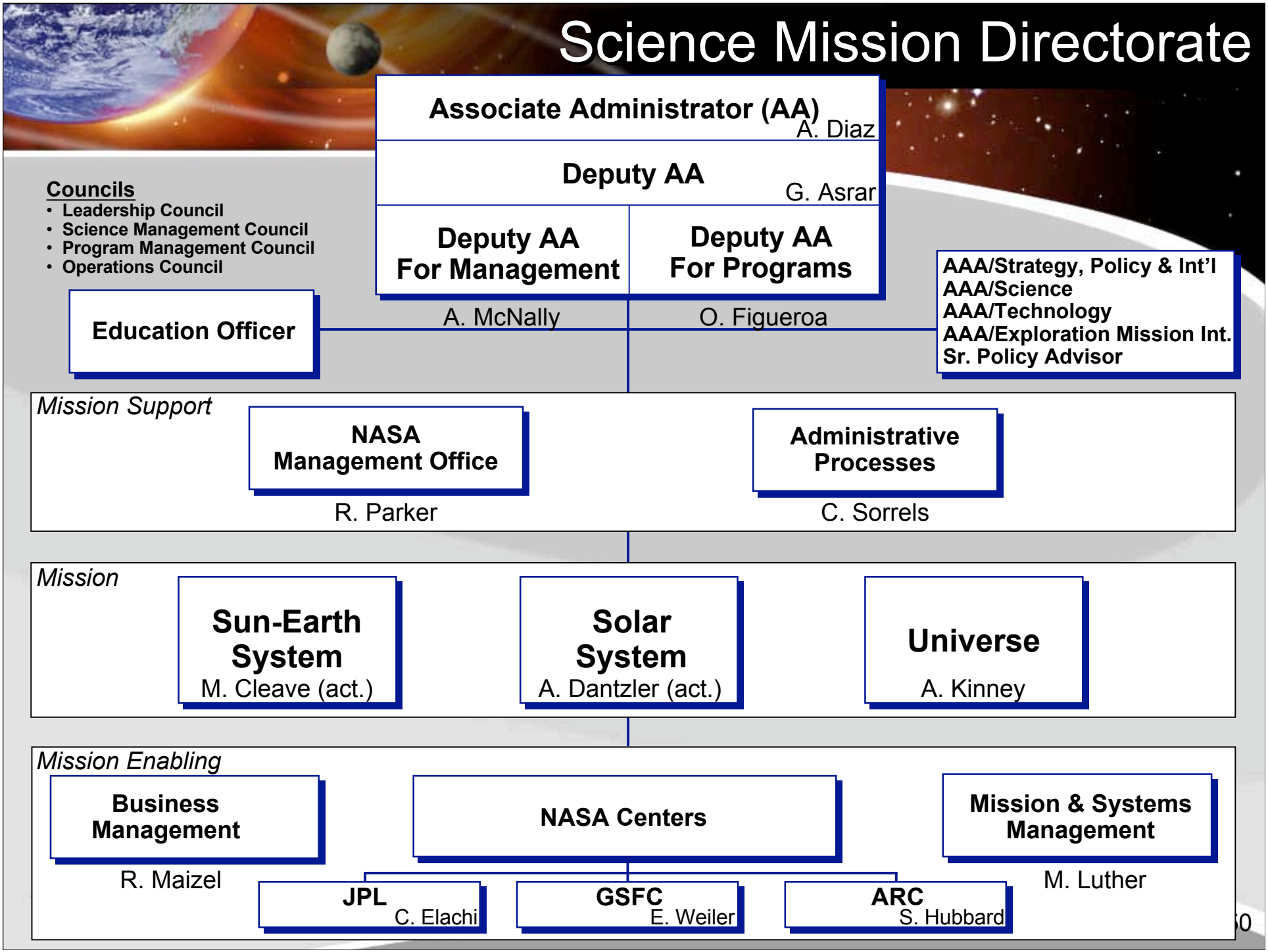


Working with our advisory committee to develop a complete picture

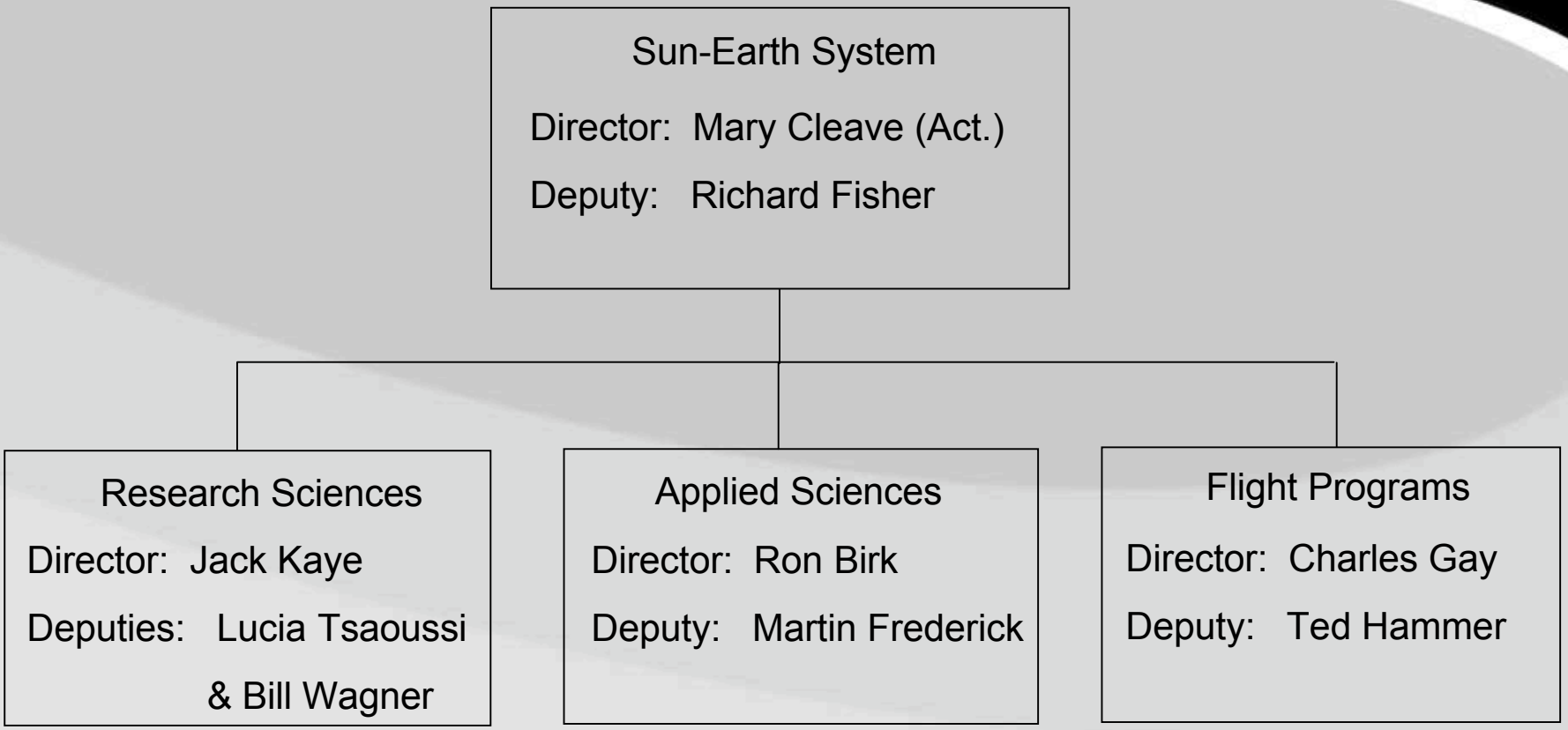
Merging Two Science Cultures

- Space Science is “Discovery-oriented”
  - Qualitative, first-time examination of distant objects
  - Tests of fundamental principals of physics
  - Robotic precursors to human exploration
  - End result is increase in scientific knowledge
  - Clear distinction of roles vis-à-vis NSF and others
- Earth Science is “Prediction-oriented”
  - Quantitative observation with precision calibration and validation
  - Seeks answers to science questions of societal importance
  - Continual, global observation impractical from the surface
  - End result is use of information to improve decision-making and inform policy-making
  - Large, complex network of partnerships

Science Mission Directorate



Sun-Earth System Division

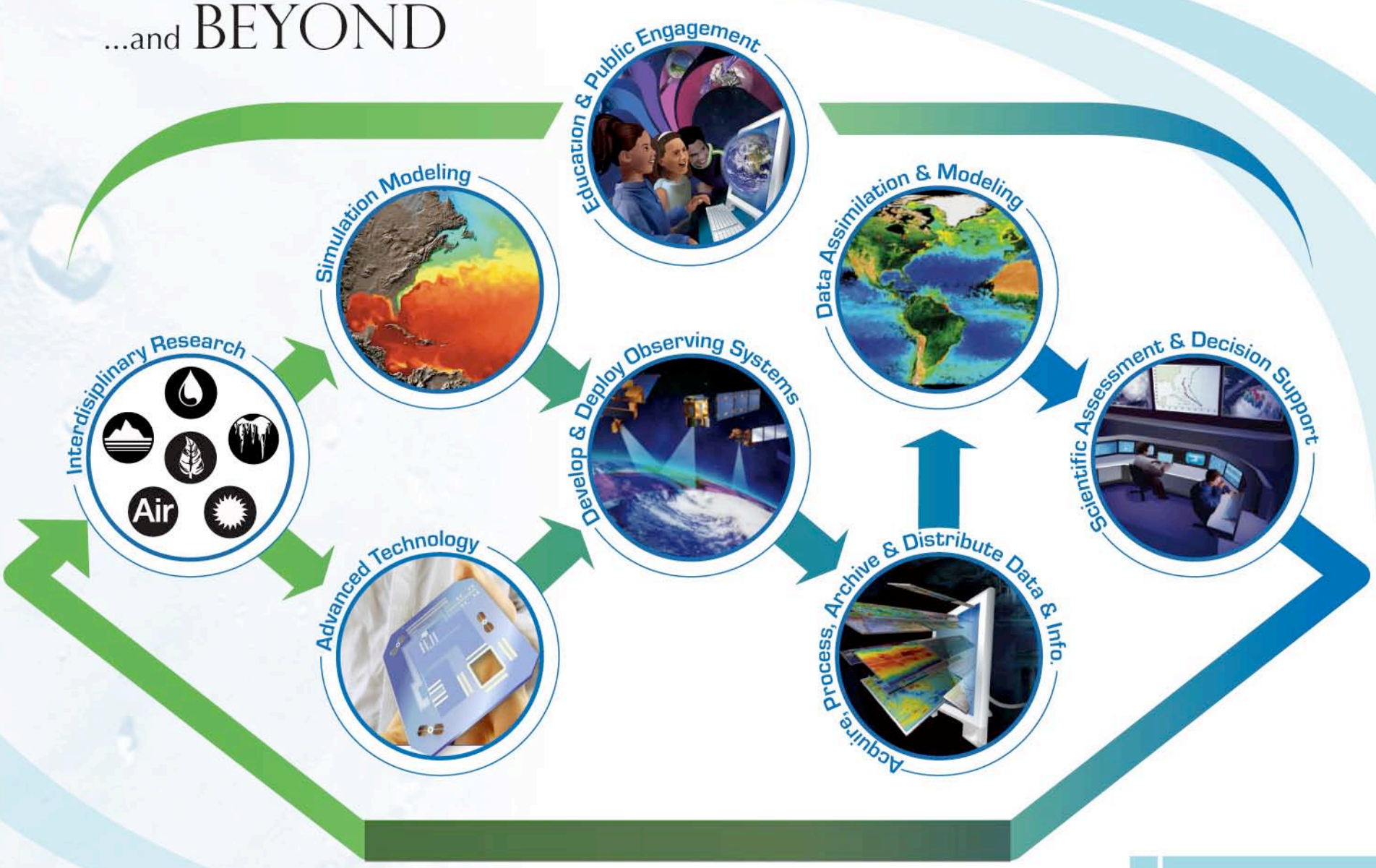


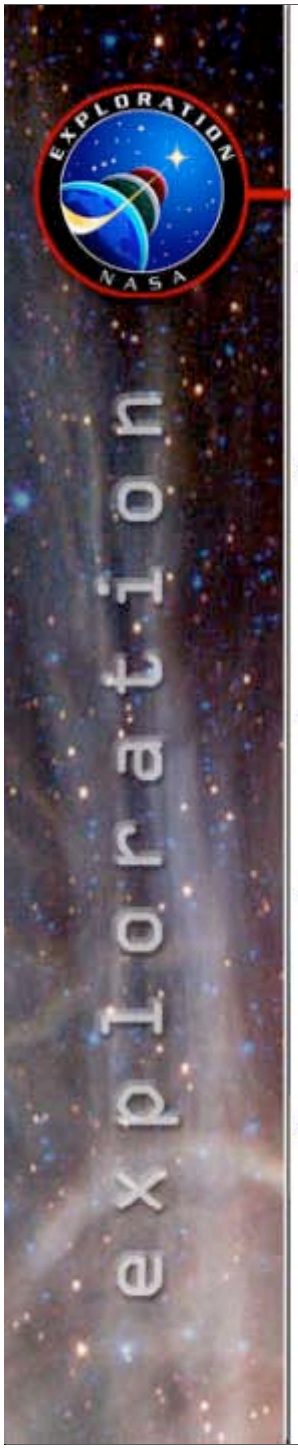
ESE Next Tier Science Questions

Variability	Forcing	Response	Consequence	Prediction
Precipitation, evaporation & cycling of water changing?	Atmospheric constituents & solar radiation on climate?	Clouds & surface hydrological processes on climate?	Weather variation related to climate variation?	Weather forecasting improvement?
Global ocean circulation varying?	Changes in land cover & land use?	Ecosystems, land cover & biogeochemical cycles?	Consequences of land cover & land use change?	Improve prediction of climate variability & change?
Global ecosystems changing?	Motions of the Earth & Earth's interior?	Changes in global ocean circulation?	Coastal region impacts?	Ozone, climate & air quality impacts of atmospheric composition?
Atmospheric composition changing?		Atmospheric trace constituents responses?	Regional air quality impacts?	Carbon cycle & ecosystem change?
Ice cover mass changing?		Sea level affected by Earth system change?		Change in water cycle dynamics?
Earth surface transformation?				Predict & mitigate natural hazards from Earth surface change?

Managing a Complex Endeavor of Scientific Exploration End-to-End

EARTH ...and BEYOND





Implementing the Vision…

Concept Exploration & Technology Progress

- **Lessons-learned reviewed and incorporated into management process**
  - Agency-wide, Orbital Space Plane, Next Generation Launch Technology
  - Lessons-learned incorporated into Risk Management Plan
- **Released Request for Information (May 04)**
  - Over 1000 responses
  - Incorporated into Concept Exploration & Refinement (CE&R) Broad Agency Announcement (BAA)
- **Released CE&R BAA (Jun 04)**
  - 37 proposals received; down-select to 11; on-board 8 Sep for 6 months to validate acquisition and requirements strategies
- **Released Intramural Call for Proposals (ICP) on System-of-Systems Technologies for Spiral 2 & beyond (May 04)**
  - 1300 Notices of Intents (NOIs) received; initial down-select to 137 full proposals; 47 projects selected (Jul 04)
- **Released Extramural BAA on System-of-Systems Technologies for Spiral 2 & beyond (Jul 04)**
  - 3700 NOIs received; initial down-select to 500 full proposals; ~ 100 projects to be selected (Nov 04)

Implementing the Vision…

System Development Accomplishments

- **Constellation System-of-Systems, CEV Preliminary Level 1 requirements and Concepts of Operations developed utilizing rigorous process:**
  - Strategy-to-Task-to-Technology (STT) process adopted as basis for prioritized investment strategy
  - Operational Advisory Group (OAG) established, populated, and led by operational users (astronauts, flight directors, logisticians, etc.) to validate requirements and priorities
  - Spirals 1, 2, 3 Requirements Identified (Decreasing definition from Spiral 1 to Spiral 3)
- **CEV RFP process initiated with target award date of Aug 05**
  - CE&R Contractor Teams influencing tech requirements & acquisition strategy, including potential commercial roles
- **Prometheus-1 (JIMO) spacecraft contract awarded September 20**
- **HSRT successfully demonstrated critical technologies**
  - Advanced Ultrasound diagnostic tool demonstrated "Telemedicine" from ISS
  - E-nose technology for air quality event monitoring successfully validated on ISS
- **Hubble Robotic Servicing Mission contract awarded October 1**

Executive Committee

- Rick Anthes, UCAR, co-chair, meteorology
- Berrien Moore, U. New Hampshire, co-chair, biogeochemical cycling
- Jim Anderson, Harvard Univ, atmospheric science, chemistry
- Bill Gail, Ball Aerospace, civil space
- Susan Cutter, U. South Carolina, hazards and risk
- Tony Hollingsworth, ECMWF, weather
- Kathie Kelly, U. Washington, physical oceanography/satellite obs
- Neal Lane, Rice, policy
- Aram Mika, Lockheed-Martin, remote sensing technology
- Warren Washington, NCAR, climate modeling
- Mary Lou Zoback, USGS, solid earth
- Risa Palm, LSU Provost, social response to natural hazards
- Otis Brown, U. Miami, physical oceanography
- Susan Avery, CIRES and CU, meteorology
- Eric Barron, Penn State, climatology and numerical modeling
- Dennis Lettenmaier, U. Washington, hydrology
- Mark Wilson, U. Michigan, infectious disease and remote sensing
- Brad Hager, MIT, solid earth

Panels-to-Disciplines Crosswalk

Decadal Survey Panels	**Atmosphere**	**Hydrosphere and Cryosphere**	**Oceans**	**Land** (land cover, ecosystems, humans)	**Solid Earth**	**Earth's Space Environment and Sun-Earth Connection**
1. Earth Science Applications and Societal Objectives	x	x	x	x	x	x
2. Terrestrial, Coastal, and Marine Ecosystems and Biodiversity	x	x	x	x		
3. Weather	x	x	x	x		x
4. Climate Variability and Change	x	x	x	x		x
5. Water Resources and the Global Hydrologic Cycle	x	x	x	x	x	
6. Human Health and Security	x	x	x	x		
7. Solid-Earth Dynamics, Natural Hazards, and Resources		x	x	x	x	x

Provisional Schedule

First committee meeting	**Nov 04**
Town halls at AGU/AMS	**Dec 04, Jan 05**
Interim report	**Jun 05**
Initial input from panels	**Jun 05**
Final input from panels	**Nov 05**
Special sessions at AGU/AMS to discuss draft report	**Dec 05, Jan 06**
Final report	**Jun 06**

For info from the NRC, see http://qp.nas.edu/decadalsurvey

Provisional Decadal Survey Panels

- Earth Science Applications & Societal Objectives
- Terrestrial, Coastal & Marine Ecosystems & Biodiversity
- Weather
- Climate Variability & Change
- Water Resources & the Global Hydrologic Cycle
- Human Health & Security
- Solid Earth Dynamics, Natural Hazards, and Resources

"Within this structure, some disciplines are not visible in the title of a given panel, but will have a role in several panels."

NRC planning white paper